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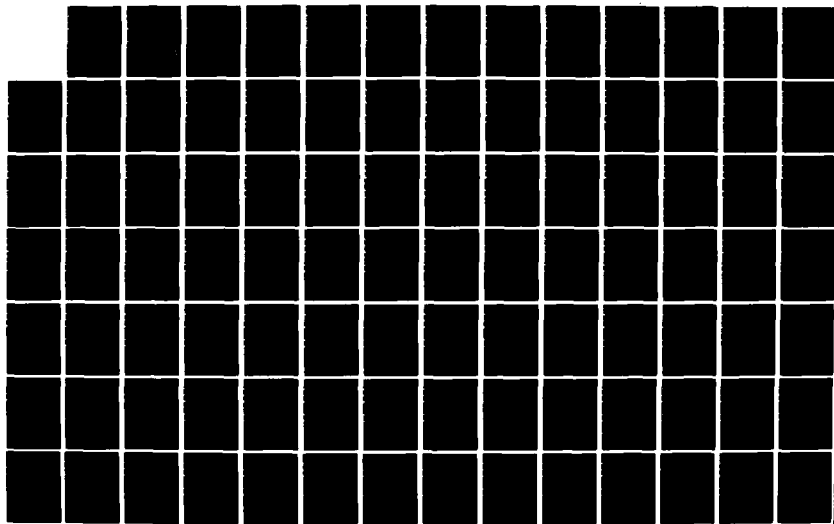
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Development of a Small-group Team Performance Taxonomy
Based on Meta-Analysis

Final Report to
Office of Naval Research

(This research was sponsored by Office of Naval Research under
Contract No. N00014-86-K-0334, Contract Authority Identification
Number 4423-012.)

Norman E. Freeberg; Donald A. Rock
Educational Testing Service
Princeton, New Jersey

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<p>A meta analysis of the small-group team performance literature was used as the basis for deriving a classification system (taxonomy) that would help specify team characteristics most relevant to performance outcomes. Such an organizing framework represents a crucial first step toward enhancing the composition and training of Navy teams.</p> <p>From 117 research studies that met the criteria for inclusion--i.e., studies using small groups functioning as "true" teams and providing suitable quantitative information--categories of dependent-independent variable linkages could be identified in terms of their effect-size magnitudes.</p> <p style="text-align: right;">(Continued)</p>					
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Those values, as well as other quantitative attributes of the aggregated studies, made it possible to: (a) define a hierarchy of relative importance for the experimental variables (e.g., task complexity, structure and practice being among those of primary influence), (b) specify several input-process-output models in a presumed causal format, and (c) identify relational gaps to be filled by future research--i.e., based on data needed for more complete model specificaiton.

The information used for this study is incorporated in a public use data set, in spreadsheet format on PC floppy disk, for user special-needs analyses and for re-analyses as new study findings become available and are incorporated in the data set.

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BACKGROUND AND PURPOSE

The volume and diversity of theoretical models, formal research and observer comment in the field of team performance over the past several decades has been extensive. Although the proliferation of literature reviews and critical analyses attest to the long-term activity and interest generated by the topic, much of the discussion has been marked by controversy, doubt and disillusion regarding the relevance of the knowledge acquired and the ability to formulate coherent directions for future research (Alexander & Cooperband, 1965; Dyer, 1984; Goldin & Thorndyke, 1980; Hall & Rizzo, 1975; Morgan, Glickman, Woodard, Blaiwes & Salas, 1986). Concern has focused on a continuing and unmet need to understand the important attributes of teams in a variety of work environments, in a way that would permit more effective prescriptions for their composition, training and management. Because of special problems engendered by military teams working in complex, often computer-mediated task environments (Allen, Chatelier, Clark & Sorenson, 1982; Kiesler, Siegal, & McGuire, 1984), the interest and support of the armed services has been especially evident from the outset, particularly in a search for efficient instructional strategies that could enhance the ability of "Crews, Groups, Teams and Units" (CGTU's) to carry out the tasks and performance objectives required for operational systems (Collins, 1977;

Denson, 1981; Rizzo, 1980; Wagner, Hibbits, & Rosenblatt, 1976). Sustained research efforts have aimed at defining manipulable variables that might influence the training process and facilitate the transfer of skills for teams as functional aggregates or single-response entities. Those areas of study have ranged from the application of team performance models based on classical S-R learning techingues involving manipulation of reinforcement contingencies (Klaus & Glaser, 1968, 1970; Klaus, Glaser & Klaus, 1966), to specification of learned behaviors in the team context attributable to individual skill development, social facilitation and task coordination (Horrocks, Heermann, & Krug, 1961; Horrocks, Krug, & Heermann, 1960), and on through efforts to define structural elements in team organization that influence the role of feedback, member interaction and communication in team output (Briggs & Johnston, 1966, 1967; Naylor & Briggs, 1965; Johnston & Howell, 1966; Kidd, 1961; Lanzetta & Roby, 1956; 1960).

However, despite useful results for the facilitation of team skill acquisition and performance having been derived from those earlier laboratory-based studies, deep skepticism remains regarding the applicability of findings from fairly abstract task settings to the more practical realities of team organization and skill acquisition in military, or other operational work settings (Hackman, 1983; Salas, Blaiwes, Reynolds, Glickman & Morgan, 1985). In Hackman's (1983) view, a "robust set of generalizations" to explain work team effectiveness--based on knowledge of input and process variables--has been lacking to the extent that "generalizations are neither strong enough nor stable enough to serve as guides for managerial practice." A recent and, hopefully, more fruitful round of research and development to alleviate some of the skepticism has been seen as evolving in the areas of

collective (group or team) vs. individual skill training and in the understanding of developmental stages in team skill acquisition (Morgan et al., 1986; Morgan, Coates, Kirby & Alluisi, 1984). But just how effective any knowledge resurgence (or the value of earlier findings) might be can, in part, be gauged by Dyer's (1984) extensive literature review of military team "and related small group" research. Along with her attempts to distill some applied principles from the existing body of knowledge, Dyer could, at the same time, cite sweeping deficiencies in the field of team performance based on "lack of adequate theory, method and systematic research", followed by a compendium of research gaps and questions for resolution that could only imply major inadequacies in the available literature. In 1985 Salas, Blaiwes, Reynolds, Glickman and Morgan continued to perceive a "lack of conceptualization and integration of team research studies," as well as inadequate measurement techniques for research dealing with team processes. And by 1986, Morgan et al. reflected much of the discontent that had been building during the previous decades with the conclusion that, for operational military purposes, research on collective (GCTU) training generally remains "beset by a variety of theoretical and practical problems." Their dissatisfaction has been sufficient to stimulate initiation of a new program of research centered around a developmental (life cycle) conception of team behavioral processes, with a reappraisal of appropriate variables, construction of new measurement techniques and the derivation and testing of longitudinal models of team training and performance.

In part, continuing disenchantment with the theoretical bases, quality and practical applicability of available team performance research, parallels

earlier criticism leveled at the much larger body of research on task-performing or problem-solving groups--within which the entity designated as "teams" represents a relatively small subset. That broader domain of group task performance has been seen as one in which unorganized data have been amassed into a poorly integrated body of research on group processes and performance (Helmreich, Bakeman, & Scherwitz, 1973; Shaw, 1961; Steiner, 1974), with efforts at finding a solution further compounded by accusations that the discipline is one that has fostered a seemingly faddish ebb and flow of study topics over a period of some 30 years (Zander, 1979). Although McGrath and Kravitz (1982) could legitimately summarize reviewers' perceptions almost a decade earlier as indicating that, for the field of small group performance, "the emperor has no clothes," any hope that their own review might offer greater promise for the 1980's was dampened by their conclusion that "the field is still a long way from having a proper balance among theory, method and data," as well as being dominated by "atheoretical (even anti-theoretical) viewpoints."

At issue in advancing knowledge of team performance is whether research dependent upon that class of small groups designated as "teams" must remain theoretically, methodologically and functionally tethered to research on the broader family of multi-person aggregates representing task-performing groups--a field characterized by observers as unwieldy and in near disarray. If the case can be made that teams represent sufficiently discrete small group entities, then more fruitful research planning integration and application might be feasible by narrowing the issues to a more manageable subset of special attributes or features that uniquely define the team and its performance characteristics.

Teams as Distinct Entities: The Problem of Definition

Most literature reviews, theoretical commentary and introductory sections of research reports that deal with the subject matter of team performance invariably recognize, at the outset, the need to differentiate teams from the more general class of task-performing groups. Implicitly understood is that all teams are task performing groups, while relatively : groups can logically be considered to represent teams on the basis of member interaction and task functions. This definitional feat, however, has not always been an easy one to accomplish, either conceptually or in research practice. Distinctive team features, generally agreed upon, consist of a goal or mission orientation, formality of structure, a requirement for member interaction stemming from task interdependence and the assignment of specific roles to members. Hallmarks of team interaction processes appear to draw upon behavioral dimensions of collaboration, coordination and communication (Hall & Rizzo, 1975; Rizzo, 1980). But, even within those features, there are variations found along a continuum of stringency and points of emphasis in the definitional terms applied.

Among the earliest attempts to differentiate the team from the broader generic entity of "small group" was that of Klaus and Glaser (1960) who specified that teams should be depicted as "relatively rigid in structure, with a high degree of member specialization and coordination in task performance and the designation of positions or assignments. Some modifications in subsequent definitions can be found in the Boguslaw and Porter (1960) view that accepts many team features specified by Klaus and Glaser, but goes on to stress a "relationship in which people generate and use work procedures" for interacting with "machines, machine procedures and

other people" in pursuing system objectives. Dyer's (1984) definition, in contrast, retains specific member roles and functions but not the requirement for formality of structure; while a shift in emphasis, away from "man-machine technical aspects of the team" to a definition that stresses team member interactions, is found in Morgan et al. (1986)--one that is, understandably, more in line with the theoretical direction of their research program on team evolution and maturation. The very process of refining the terms used to distinguish teams from groups has also been viewed as a research task in its own right (Collins, 1977), one that not only serves to delineate a concept but also helps to sharpen and define the variables most relevant to team performance research (Dyer, 1984).

After paying homage to a set of functional attributes by which teams might be defined as distinct entities, however, many reviewers and researchers have gone on to discuss theoretical issues and findings from a so-called "team performance literature" that is entirely interwoven with, if not dominated by, an array of studies failing to conform to even the most flexible definitional guidelines for the team concept. In part, the confusions follow from interchangeable uses of the words "team" and "group" by investigators that lead to obvious difficulty in deciding "if researchers are really studying the same entity" (Dyer, 1984). In some cases use of the term "team" has appeared to be stimulated by its being in vogue, as an apparent "catchword" since the late 1960's, for studies involving groups engaged in problem-solving situations that could hardly be considered as

representative of a task-interdependent team.¹ In other instances, investigators have expressed a stated--often unexplained--disregard of any such distinctions in their study efforts. Nadler and Berger (1981), for example, in an attempt to develop a classification system for Navy teams, present an annotated listing of team definitions from the literature that they concede present critical elements of teams useful for defining team "taxonomic dimensions." But they then go on simply to "mention" that "the terms team and group are to be considered synonymous for purposes of this research"--with no explanation of why that decision is reached. Still other investigators have used the terms interchangeably throughout a series of continuing research studies, such as those conducted in the area of work-team effectiveness (Gersick, 1983; Hackman, 1983), based on an expressed personal choice to consider the group-team distinction as essentially irrelevant to their work (Hackman, 1987). Attempts to synthesize small-group research findings, in general, as somehow applicable to team training technology (typified by Collin's [1977] narrative review), might also raise questions on definitional and conceptual grounds. Under any circumstance, adverse effects of confusions in terminology and methodology can seriously hinder the ability to organize research results for the formulation of coherent theories of team performance and training (Dyer, 1984). But, even where agreement is obtained, regarding the attributes that uniquely define individuals working in consort as a team, there are sticking points that remain in any attempt to

¹A salient example of cavalier treatment of the terms "team" and "group" appears in an article by Goldman, Stockbauer & McAuliffe (1977) dealing with an evident group (non-team) problem-solving situation, wherein only the term "group" appears in the study title and abstract, while the word "team" is used repeatedly and almost exclusively in the body of the article.

organize and integrate a literature of significant scope into a useful framework for theoretical or applied purposes.

Models, Taxonomies and Organizing Schema

Probably the major stimulus to seeking some form of organizing structure in the area of team performance and training has followed from the 1976 report of the Defense Science Board Task Force on Training Technology that specified the need "...for systematic R & D to develop a taxonomy of operational force elements (crews, groups, teams and units) and on methods for controlling training variables...." (1976). That message has since been heeded and further amplified, arising as the primary and "pervasive concern" of participants at a major U.S. Navy-sponsored symposium on team performance--one that served to lead off the current decade in terms of theoretical-methodological concerns to be addressed and practical research directions to be followed (Golden & Thorndyke, 1980). A requirement for a "taxonomy of teams based on their critical attributes" was viewed as the "first step" in a research program, with likely benefits to be realized in the form of improved research utility, facilitation of the choice of operational research variables for study and the capability of generalizing research results across equivalent classes of teams and settings. Few clues as to the specific procedures involved in constructing and applying some form of taxonomic/classification system, in order to achieve such sweeping benefits, were provided in the symposium papers. Nevertheless, the broad challenge was taken up by Knerr, Nadler and Berger (1980) and Nadler and Berger (1981), in their subsequent efforts to construct a taxonomy, or classification system, for Navy teams, based on defining "significant variations along pertinent dimensions." The authors review different

meanings applied to the term "taxonomy" as the label for any organizing system involving the ordering of phenomena on some form of relational basis and classificatory rules, along key dimensions. Their summaries of prior behavioral taxonomies deal with such attempts as Bloom's (1956) taxonomy of educational objectives (largely a categorization of educational assessment materials and techniques), --Naylor and Dickinson's (1969) taxonomy of team performance (more of a limited model, with variables subsumed under the three categories of task structure, work structure and communication structure) and Fleishman's (1967) categorization of psychomotor and physical proficiency factors (essentially a set of factor-analytically derived dimensions, rather than a defined hierarchial or coherent classification system).

The value of organizing schema of this sort has been questioned by Travers (1980) who, in his critical review of the history of taxonomic science, sees them as lending a spurious reality to the ordering of convenient constructs in what has often been no more than Aristotelian cataloging of observable attributes. He takes the Bloom Educational Taxonomy to task as typical in its lack of theoretical underpinnings and weakness in logical structure or rules of order, that would more appropriately permit it to be designated as a simple inventory. Caveats regarding the meaning and vagueness of usage that mark the terms "taxonomy," "classification," and "inventory" and their ability to retard scientific advances through a "chaos of nomenclature," are summarized by Travers, who prefers the term "classification" as one that is better understood and more definable than the much abused, pedantic and often poorly defined term "taxonomy." A more useful classification system in Travers' view is one that provides a hierarchial arrangement of categories and their relations in terms of

operationally definable concepts--e.g., based to some extent on Piaget's analyses and structure of logical thinking (Inhelder & Piaget, 1956). From such a perspective, it would be difficult to understand the bases on which the Nadler and Berger (1981) "Naval Team Taxonomy Model" is arrived at in terms of existing findings in the team performance literature, the relations between the elements or dimensions listed, and how an orderly development or integration of further knowledge could move beyond their "catalog" (inventory) of team behaviors.

Failure to provide direct empirical evidence to link the variables, of what appears as a static input-process-output systems model of team performance (or at least a statement of formal properties that underlie the derivation of the model), represents a basic deficiency not only of the Nadler and Berger classification system, but of a host of other team performance models or paradigms that have proliferated in the literature, with little to substantiate their accuracy or utility. Such formal representations, outlining or diagramming sets of variables of presumed importance, have appeared, for example, as models of "Team Skills Training" (Turney, Cohen & Greenberg, 1981); as so-called "general systems" models of team performance (Morgan et al., 1968) and as team skill retention models (Knerr, Berger & Popelka, 1979). Others have been based on specific training environments or strategies, as in the stimulus-response and "organismic" (emergent) team models defined by Alexander and Cooperband (1977), or Rasmussen's (1972) team behavior modification system. Additionally, there are all-encompassing "meta models" that contain team performance variables embedded in models of larger organizational contexts (Salas et al., 1985). The bases for specifying the structure of such models, the nature of the

hierarchy and relative value of the variables, and the assumptions on which their hypothesized relations (interactions) are based remain obscure--or at least seem to be inferred from highly generalized, but unspecified, deductions by the model builder.

A far more promising, empirically-based, approach to model building and the organization of relevant constructs, is found in the careful definition of variables and their relationships (as specified in the literature) which are then used to define and test a causal, or structural, model using path analysis (Daley, 1980). The six variables incorporated in Daley's recursive path model, for example, provide evidence to define the influences of a number of key concepts such as team coordination and cohesiveness, that have been explored in prior team research or specified in other hypothesized models.

Meta-Analysis as an Organizing Tool

The quantitative methods for integrating research findings across independent studies, that have come to be known as meta-analyses, follow from initial use of that term and the development of a number of analytical techniques by Smith and Glass (1977). Where there is some common theoretical basis, or conceptual hypothesis encompassing similar measurement constructs, results of a series of studies can be combined in a statistical summary of the effects of experimental treatment on outcome. The process, seen as a more rigorous alternative to conventional narrative literature reviews, stems from a generally agreed-upon set of methodologies for applying quantitative analyses to broad segments of research results from the social sciences (Glass, 1976; Glass, McGraw & Smith, 1981; Wilson, 1981) or other scientific

disciplines (Hedges, 1987). In essence, stronger conclusions can be reached based on aggregated studies and their associated aggregated statistics.

Customarily, the analysis involves collection of a relatively comprehensive set of studies on a topic that might fit an underlying theoretical model (with associated hypotheses), from which criteria for a defined research domain can be specified and the suitable studies identified and acquired. Statistical findings reported in each study are subjected to analyses that permit determining a common metric or "scale-free" index of the magnitude of the effect (the effect size) or "the degree to which the phenomenon is present in the population," and conversely, "the specific degree to which the null hypothesis is false" (Cohen, 1977). A primary advantage of such syntheses of study information, not available in traditional reviews," lies in its descriptive power to relate conditions that vary across studies to outcomes" (Wilson, 1981). Such relationships between effect sizes and study attributes of importance permit systematic examination of: (1) the suitability of classes of differing studies in terms of the relative value that they possess for explaining effect size, (2) the criteria for aggregating results from the different classes, and (3) important clues to interpretation of effect sizes within a class.

Cautions and significant limitations are often cited in the conduct and interpretation of meta-analyses. These deal with issues in validity or representativeness of studies retrieved for the given topic, completeness of summary statistics in the studies available for the analyses, problems in the choice and application of appropriate analytical techniques by the reviewer, study selection and reporting biases, and the sheer cost and skill level involved in the acquisition, coding and analytical procedures required

(Bullock & Syvanteck, 1985; Cooper, 1984). Despite the limitations, however, a quantitative approach to combining findings across independent studies remains a clear choice over the discursive review as a source of rigorous and objective summary findings, since it serves as a way of integrating information into "abstract, general causal and relational form" (Wilson, 1984), of providing more fruitful directions for formulating theory and of planning future research (Cooper, 1984).

However, attempts to broaden the interpretive value and application of meta-analyses results for such purposes--including attempts to define some form of organizing structure, or classification system--presents something of a paradox regarding the scope of study literature to be included in the quantitative review. That is, most meta-analyses tend to focus on a set of carefully circumscribed constructs within a common conceptual hypothesis and carefully defined area of study. By contrast, an intent to use the integrative review for purposes of developing a classification system implies broad coverage of the available research information in a way that cuts across numerous categories of variables. Thus, the present study requires aiming at a wide range of research literature dealing with input, mediating (process) and output (performance outcome) variables in team research, while still providing the capability of focusing on a narrower portion of the study domain, in order to deal with desired common hypotheses at a conceptual level that provides useful interpretation of specific findings.

Study Purpose

If there is to be cumulative benefit from the extensive prior research available in the field of team performance, then the integrative or organizing approach realizable with meta-analysis should be applied to the

best of the available literature in order to: (1) provide a functional information base that could help define an empirically defensible classification system and associated models derived from relevant and measurable variables, (2) specify where research knowledge is lacking with respect to those formal structures, and (3) provide a capability for incorporating new findings into any classification system, in ways that can add to its utility.

Since the products of meta-analysis provide summary statistical information regarding independent-dependent variable linkages, these can serve as the foundation for a useful organizing framework, one that represents a crucial first step toward enhancing the composition and training of Navy teams. The intent to develop such a structure is dependent upon defining: (a) the most frequently occurring linkages or associations between categories of dependent and independent variables--as determined for aggregated studies--and the strength of those linkages in terms of their effect size, (b) linked categories that are underrepresented in the available research derived from the literature--i.e., existing gaps in terms of promising variables that should be studied more extensively, (c) the relationships between observed study characteristics and the magnitude of effects achieved (e.g., between effect size and study quality, sample size, publication source, etc.)--so as to help focus on the "best" of the data to be used in any analytically derived system, and (d) models constructed on the basis of the magnitude of the effect sizes found for variable linkages and the contrasts of these models with theories or hypothesized models in the literature--i.e., do some of the hypothesized links suggested by others prove to have essentially zero effects in the literature aggregated for

meta-analysis? This ability to specify crucial linkages over a wide range of measurement constructs can be seen to take on special advantages, in regard to team performance, because of the relatively large number of studies in the field and their relatively poor conceptual integration (Salas, Blaiwes, Reynolds, Glickman & Morgan, 1985).

Study findings chosen for incorporation in the meta-analysis are to be obtained from that segment of the research literature dealing exclusively with task-interacting small groups that are reasonably definable as teams (based on customarily used criteria) and for which measured performance outputs are based on the team as a unitary entity. The study data compiled is intended to be available to others in a readily analyzable (manipulable) format, suitable for public use (i.e., on diskette, for personal computer use in a spreadsheet format) and amenable to user reanalysis, in order to test specific competing hypotheses or analyze subsets of findings that deal with topics of special interest. In addition, as an organized data set that is to contain descriptive and categorical information about study variables--as well as study characteristics and effect size magnitudes--the system would be one to which information can be added as relevant new team research findings become available, thus permitting modifications to any classification system derived, based on new or strengthened variable linkages uncovered.

METHOD

Literature Search and Acquisition

The validity of the meta-analytic process is grounded in the scope of applicable research literature that can be identified and the accessibility of the documentation. The extensive body of small-group performance literature, within which the team studies are embedded, serves to complicate

and broaden the document search requirements--largely attributable to definitional problems discussed in the previous section. In addition, references to small-group team performance come under many guises in the available computer-based search systems, wherein successful retrieval depends upon the user's ability to choose appropriate (i.e., key word) descriptors as single terms and combinations, or sets, of terms. The logical structures of the on-line systems can present a variety of complexities in attempts to choose appropriate descriptors which identify desired documents that utilize the designation "team" in their titles, abstracts, or subject matter relevant to that term.²

Thus, many of what would generally be categorized as team performance studies, can be found under such key words as "teamwork," "unit," "crew," "workgroup," "dyads," "triads," and "leadership." However, it is also necessary to identify documents containing substantive research rather than those involving only commentary or surveys and research reviews (found to be an overwhelming proportion of the literature) if they are to fit the empirically-based requirements for meta-analysis. Consequently, other descriptors utilized included "task performance," "research," and "empirical." In addition, because of a desire to examine some aspects of team "training" or "learning", those key words were also included for sorting purposes as part of the search strategy. A problem that can arise in querying the search systems is that leaving the descriptors too few or too generalized opens a floodgate of unwanted titles and abstracts to be reviewed relevant to teams and groups; while combining too many sets (connected by

²For consideration of on-line search strategies that may be adapted for research retrieval, as well as their potential impact on validity issues in meta-analyses, see Cooper (1984) and Simpson (1987).

"and" statements) produces too much specificity and loss of desirable material. The search process can thus become iterative, often highly repetitive, costly and time consuming.³

Added difficulties in accessing the team performance literature stem from its great diversity in regard to both the types of documents in which the studies appear and the sources from which they must be retrieved. That is, most meta-analyses, by virtue of their topics of inquiry, are able to depend heavily on archival (published) journals which, as refereed studies, are not only more readily obtainable but are more likely to be written in a structured format and to contain quantitative information more adaptable to meta-analysis needs. By contrast, the team performance literature is replete with unpublished manuscripts and technical papers, many of which are funded by governmental (usually military) organizations and carried out by industrial contractors, private research firms, and the governmental agencies themselves. Such documents do not enter conventional abstract systems as readily, or as widely, as published materials. It is also necessary to forego a relatively small set of team studies of military origin, that prove too difficult to identify or obtain because of their security classification.

Using the Dialog Information Services network for the computer-based search, the major document information systems were queried (i.e., the National Technical Information Center, Educational Resources Information Centers, Psych Info, Psych Alert, Psychological Abstracts, Sociological

³Ability to separate the team-oriented studies from small-group studies, in general, is one with extensive logistical consequences for meta-analysis. When one considers that Hare's (1976) "Handbook of Small Group Research" contains over 6,000 references (to which a substantial number are likely to have been added over the ensuing years that encompass the present meta-analysis time frame).

Abstracts). In addition, manual searches were undertaken for bibliographies found in major literature review publications (e.g., Psychological Review). In all, some 3,300 abstracts were obtained from the on-line search systems based on various combinations and recombinations of descriptors previously mentioned.

Literature Organization and Integration

From a review of the abstracts and available bibliographies, a set of subject categories was defined that proved useful, initially, for organizing and acquiring the documents and for their management within a data system. The desired studies, whether laboratory or field-based, were classified (with obvious overlap) as dealing with (1) military and non-military teams (under laboratory and operational conditions); (2) theory, reviews, methodology, and models; (3) cooperative small-group learning in education (including team gaming and simulation); (4) work groups; (5) nuclear power plant operators functioning in teams; (6) civil aviation and space flight crew performance; and (7) small-group sports teams (e.g., basketball, hockey). Selected researchers, whose experience fell within the particular categories, were also contacted--usually by phone--to help identify recent work in their respective specialties of team performance and to provide advice regarding study documents or sources that should be considered essential.

A set of potentially useful references (somewhat in excess of 700) were identified from the above sequence of activities. These references were believed to represent studies having statistical information dealing with task-performing small groups functioning as teams and covering a time period of approximately 25 years from 1960 to 1985. It was possible, within the constraints of available time and resources, to obtain 547 of those study

documents. Among the serious limitations on acquisition of the desired studies was that a number of documents were simply out-of-print with copies no longer available from either the initiating sources (e.g., military or industrial organizations) or the major document services such as NTIS and Defense Technical Information Center (DTIC). In addition, foreign documents identified reflected a degree of recent research activity on teams as work groups--particularly in Russia and several of the other eastern European nations (Poland, Rumania, Czechoslovakia). But, in many of those instances the titles and abstracts were translated into English while the article content was not. The expense and time that would have been involved in obtaining translations, on the chance that the study contained usable data for meta-analysis purposes, was generally prohibitive.

Criteria for Document Inclusion in the Meta-Analysis

Incorporation of any document in the final data set was based on the following criteria: First and foremost, it had to be a quantitatively-based formal research study in the general area of team performance--i.e., paper included all described a study intent and some form of research design, reported results based on findings from data gathered (preferably utilizing some form of statistical analysis, although raw data were analyzed where necessary), and in some way measured performance outcomes involving teams as a working unit or single entity. For many of the acquired documents, the major criterion involving presentation of quantitative statistical information--that one might have assumed as likely from reading the abstract--proved to be unsubstantiated. A significant proportion of these materials contained little more than anecdote or commentary about team performance issues, general summaries or literature reviews of research

findings, survey results dealing with future needs in team research and studies dealing with the development of new measurement techniques applicable for team research purposes.

A second requirement was that the study deal with task-performing groups falling within reasonably flexible guidelines to qualify as a "team" in terms of the task(s) performed, the degree of member interdependence, and the organizational structure. Study samples were to be comprised of young adults or adults. Many of the studies rejected from the acquired document pool were based on loosely organized problem-solving groups, often mistakenly referred to as teams in titles, abstracts, or content, 'at within which any single group member could perform the task(s) required of the group--i.e., solve the problem. In other studies the outcomes measured were not those reflecting the performance of the team as a single entity. Notable, as a body of literature that has used the team designation freely but that does not meet a number of the essential elements of team definitional criteria for our study purposes, is one dealing with "cooperative small-group learning" (Johnson & Johnson, 1984; Slavin, 1980). Those studies had to be excluded since they are confined primarily to samples of young (grade school) children who spend time in cooperative learning groups as "teams" (wherein the nature of specific member roles in those "team" training sessions are largely unspecified)--and then go on to measure individual achievement only following the group learning experience.⁴

Another class of studies purporting to measure team performance, that was not incorporated in the data set, dealt with so-called "simulated" or

⁴Some few studies classifiable in that category did, however, deal with adults and did measure team performance outcomes; these were mostly in management simulation and gaming situations.

"contrived" teams wherein the individual works in isolation on a task, but is led by the experimenter to believe that he or she is performing as part of a team (Johnston, 1967; Johnston & Howell, 1966; Johnston & Nawrocki, 1966; Short, Cotton & Klaus, 1968; Waag & Holcomb, 1972). Various forms of task information are fed back by the experimenter who may modify different aspects of the "team" task and/or other associated variables intended to influence the individual's performance in some hypothesized way. Still other types of team-designated research found unsuitable consisted of studies utilizing groups living in long-term isolation settings (Chiles, Alluisi & Adams, 1968; Emurian & Brady, 1981, 1983; Emurian, Emurian & Brady, 1978). Such studies, intended as generalizable to military and space flight crews carrying out tasks over extended periods of days or weeks, involved social and work arrangements that rarely required team performance efforts on a defined multi-person task for which group outcomes were measured as dependent variables (the performance being represented, instead, by some composite or average of individual member performance in each crew).

A third criterion was that the study deal exclusively with "small" groups, defined as ranging from two to six members. However, studies wherein group size was dealt with as an independent variable, for contrasting individual performance with small-group teams, were included. In some instances, what appeared to be promising studies had to be discarded for military and industrial work groups (e.g., a shipboard CIC, ASW operation, clothing manufacturing plant) because the nature of the data presentation permitted only large-team performance determinations, despite a clearly defined and integral role of small-group subteams.

The fourth and final requirement for inclusion was that the data-based results of the study--in order to be amenable to meta-analysis--be reported in a way that provided either (1) a usable effect size, directly, in the form of a product-moment correlation, or (2) statistical information needed to compute such a relationship (including Eta where appropriate) between some form of team characteristic and a team performance criterion--i.e., from means and standard deviations, t-tests, F-ratios and mean squares or sums of squares--and/or (3) information needed to determine a level of statistical significance if not already provided (i.e., some specification of p values for defined variables).⁵

Of the 547 documents acquired, the number of studies that met the above criteria for inclusion in the final document set used for the meta-analysis totaled 117, for a yield of 21 percent. Multiple findings, available from most of those 117 studies, resulted in a total of 667 individual findings that were incorporated in the data base (i.e., in spreadsheet format on diskette).

Document Coding and Data Organization

A code sheet was designed to incorporate the information needed from each usable study document in order to: (a) carry out the meta-analysis, (b) define the variable categories for the classification system, and (c) provide public users of the data set with sufficient information to tailor additional analyses for their own purposes. (A copy of the code sheet

⁵Quantitatively-based studies having only a level of significance (p-value) available--but having a defined research design and specified study variables--were incorporated in the data set for possible future application in broader, but less stringent, meta-analyses (e.g., using vote counting techniques only). However, the meta-analysis conducted for the present study purpose is based solely on those findings for which an effect size was provided or derivable from the available statistics.

and the forms of information entered is shown in Appendix A.) Basic study data were recorded for document and coder ID;⁶ study source (journal article, book dissertation, etc.), year of publication, size of team used as the study unit, whether the research was based on a field or laboratory study, and whether subjects were military or non-military personnel. This was followed by primary statistical information reported in the study (e.g., product-moment r , F -ratio, ANOVA sum of squares, means and SD's, p values, sample sizes, and degrees of freedom in numerator and denominator). It was also considered of value to rate the quality of the studies, since in an initial perusal of the documents there appeared to be wide variation in their technical suitability as research reports. The major dimensions on which the studies appeared to vary and the ones chosen for rating purposes were:

- (a) Substantive interest (or value)--as a topic of inquiry for small-group team performance research. The primary consideration is one of the degree to which the stated study purpose(s) and constructs or variables chosen to be assessed would add to the clarification of problems of recognized importance in the field--usually evident in the authors' ability to integrate the problem under investigation with other findings and theoretical or practical issues remaining to be resolved.
- (b) Design/methodology--as an overall judgment of how well the author obtained, analyzed and organized the quantitative evidence to support the study intent. This included general aspects of the measurement techniques used to assess the intended constructs, data gathering procedures, and sample adequacy; as well as the suitability of the research design chosen (including the clarity of design explanation), and the approach utilized for data analysis.
- (c) Reporting of data--judged as to the adequacy of quantitative information presented to support the discussion of results and conclusions reached. Of specific concern was the extent to which numerical values associated with the findings from the study design were provided (i.e., means, SD's, t 's, F -ratios, sums of squares, etc); as opposed to no more than verbal commentary about some

⁶There were three document coders, all at professional scientist level, two of whom were the study project directors.

portion of the data, or only partial reporting of numerical values (including graphic presentations from which it proved almost impossible to recover data, such as means, with sufficient accuracy).

Effect sizes were manually computed for each study finding and entered on the codesheet (r's and, where appropriate with more than a single df in the numerator, Eta's). A "vote", which indicated whether the finding was statistically nonsignificant (vote = 0) or significant (vote = 1) at the $p = .05$ level or better, was entered for every study in the data set.

The remaining form of information, entered as part of the coding process, was somewhat specific to the present study intent--i.e., to utilize the quantitative research review for an empirically-based classification system. That information consists of a verbal description of the independent and dependent study variables and of the separate findings. Use of a spreadsheet format (Lotus 1.2.3) that incorporates such verbal entries, enables the user to obtain limited, but concise, explanatory information about the nature of the particular study and its findings to a degree not feasible from the purely numerical data entries. Those verbal descriptions are also converted to numerically-coded categories, as summarized below, in order to provide manipulable data for the meta-analyses and the resulting study cross-classification system that serves as the basis of a taxonomy.

Description and Categorization of the Variables

It will be evident, from the categorization and description of the dependent and independent variables below (as defined from the studies that entered into the meta-analysis), that most of them can also be found in various theoretical models appearing throughout the team performance literature of the past several decades. There are 12 categories of dependent variables (performance outcomes), definable from the studies that comprise

the present data set: (1) Team Accuracy of problem or task solution, (2) Time required to achieve task solution, (3) the Quantity or amount of product produced by the team, (4) the extent of Task Transfer by the team to other settings or skills, (5) Solution Agreement between team members, (6) Originality of task solutions shown by the team, (7) team Cohesiveness as degree of personal attraction between members and willingness to remain in the group, (8) team ability to perform task(s) in a Coordinated fashion or to use methods for integrating task components properly among the members, (9) member perceived Satisfaction, (10) suitability of Interaction or Communication achieved (for various modes or categories of communication), (11) Trials to Acquisition or extinction, (12) overall team quality or performance Proficiency (usually a single composite score or rating).

In contrast to the number of dependent variables, the set of independent variables definable from usable team research studies is considerably larger (as might be expected). There were 25 identifiable categories of independent variables that are conveniently and arbitrarily grouped under three broad classes or dimensions consisting of:

- A. Team member characteristics--within which there are variables of: (1) sex, (2) team size, (3) prior experience with or knowledge of the task, (4) aptitude or academic ability (of the team members as a group or of a leader), (5) member motivation, (6) personality characteristics (applicable to members overall as a team or based on differences between members), and (7) length of team member association (time worked together).
- B. Team task characteristics--consisting of: (8) complexity of learning or task presentation, (9) task load (rate of presentation as time pressure or other imposed stresses), (10) task fidelity (comparability to "real world" tasks), (11) type of task structure (as serial, parallel or hybrid), (12) feedback/knowledge of results, (13) imposition of goal or performance expectations.

C. Team organization--dealing with (14) communication structure (wheel, circle, line, etc.), (15) cooperation vs. competition (among members or between teams), (16) assigned roles and role stratification, (17) individual vs. team or subteam contrasts, (18) cohesiveness or personal attraction and compatability, (19) coordination or linking and integration of member functions,⁷ (20) interaction/communication (mode or channel and category), (21) team member homogeneity/heterogeneity (in terms of cognitive or noncognitive abilities and characteristics), (23) team member replacement ("perturbation"), (24) team vs. automatic (e.g., computer) control, (25) supervision and leadership variations (e.g., style or ability). A remaining category of miscellaneous, or relatively unique independent variables found to be associated with only a single study, was utilized. This comprised only six studies for which effect sizes were available.⁸

Spreadsheet Data and Format

The data from the codesheets were entered on a PC floppy disk in a spreadsheet format, using Lotus 1.2.3 (2.01) to accommodate a total of 26 fields and 667 records (findings) that comprise the total data set. A listing of the field headings under each of 25 columns by their letter designation is presented in Appendix C. The organization of the data file and the nature of the information presented should enable public users of the data set to manipulate the basic information to meet their particular analytical requirements or interests (e.g., for separate meta-analyses of different subsets of studies; use of particular blocking variables, etc.). It should be noted that the file is sorted with respect to independent dependent variable codes--in columns "W" and "X". That is, dependent-independent variables are sorted within each of the variables with which they

⁷Although it is desirable to specify dependent and independent variable categories as distinct from one another as possible, some research studies used variables such as Cohesiveness and Coordination as outcomes, while others used them as independent variables.

⁸The code designations for all dependent and independent variables, as they appeared in the spreadsheet data file, are presented in Appendix B.

were cross-classifiable. Study ID codes shown in column A refer to the studies referenced in Appendix D, each of which can be matched to the spreadsheet on the basis of the same ID code number.

Statistical Basis for Inclusion

Two screening procedures were used for this meta-analysis. Studies were first screened for eligibility for entry into the data base using the general rules discussed earlier, which will only be referred to here when they bear directly on certain statistically-based decisions with respect to inclusion or exclusion. The rules for the second screening dealt with decisions about inclusion or exclusion in the steps having to do with combining effects from independent studies, i.e., the formal meta-analysis.

Within the context of the two primary study goals: (1) the development of an initial taxonomy of small-group team studies and (2) the estimation of summary effect sizes from combining studies, there are conflicting statistical implications that require clarification. Because of the judgments and decisions that the meta-analyst must make regarding which studies are appropriate to include in a quantitative review, meta-analysts have been criticized for mixing studies that measure "apples" and "oranges" (Wolf, 1986). Since one of the present study goals was to develop an initial taxonomy and thus, purposely, include studies that are heterogeneous with respect to both hypothesis being tested and variables used, the apples-and-oranges analogy would, at first glance, seem to apply here. A response to this type of criticism is that a good meta-analyst capitalizes on this by coding apples as apples and oranges as oranges and then analyzing these categories separately (Green & Hall, 1984). This procedure of including diverse studies and then grouping those studies according to similarities in

variables being used and the hypothesis being tested is, of course, one way to form meaningful taxonomic groupings.

Statistical rules for inclusion in the present analysis were:

- (1) If the study effect is reported from an analysis of variance, the estimate of the effect must have one degree of freedom in the numerator (i.e., a contrast between two groups) and the degrees of freedom for error (or the sample sizes) must also be reported. The reported F's, t's, or sums of squares were then converted to product moment correlation coefficients.
- (2) If the study effect is reported as a correlation, then the sample size must also be reported.
- (3) A study can furnish only one effect in any one independent/dependent variable category. If a study furnished more than one effect, the effects were first transformed to product moment correlations and they, in turn, were transformed using Fisher's "z", and then finally, the mean effect for that study was computed and recorded. Restructuring each study to supply no more than one effect to a particular independent/dependent category guaranteed that only independent estimates of effects would be combined when estimating the average effect by category and the associated statistical significance.

While Eta coefficients, i.e., ANOVA's with two or more degrees of freedom in the numerator, were recorded in the public use data base for completeness, they were not used in the formal meta-analysis. It would not be proper to combine nonlinear estimates, such as Eta's, with the linear product-moment coefficients. In addition to the statistical problem associated with such a combination, one cannot, in general, group and interpret nonlinear functions that may have different shapes.

The requirement that sample size or that the error degrees-of-freedom be reported, was necessary in order that estimates of effects could be weighted by their "n" size when being combined to get a mean effect within independent/dependent variable categories. We felt that since the variance of any one given effect size is inversely proportional to its sample size,

and the study n 's varied considerably, the weighted estimates would be the more efficient estimates.

Effect sizes for interactions whether they were based on Eta's or product-moment correlations were included in the data base, but they were not included in the formal meta-analysis. Interactions were excluded for two primary reasons. First, many of the interactions had more than two degrees of freedom in the numerator (Eta's) and thus could not be grouped properly with linear product-moment correlations as discussed above. Secondly and more importantly, most studies did not provide sufficient information to estimate effect sizes based on the "simple main effects."

Methodology

Once the subset of studies from the data base were selected on the basis of the above inclusion rules, the study effects (i.e., Fisher z 's weighted by their respective n 's) were then averaged within each independent/dependent category. More specifically:

$$\bar{z}_k = w_1 z_1 + \dots + w_p z_p \quad (1)$$

Where z = the weighted average in the k th independent/dependent category and

$$w_i = (n_i - 3) / \sum_{i=1}^p (n_i - 3).$$

Since a study could contribute only one effect estimate to each category, the average was based on independent estimates. These average effects in each independent/dependent category were then retransformed back to product-moment correlations. These became the final category-effect sizes. Other

approaches to weighting the study estimates were also investigated. In particular, each study was weighted by a rating that described the quality of the study design. This procedure, while intuitively appealing, yielded almost the same rank ordering of studies as did the more statistically defensible procedure of weighting by the n size. The correlation between the two weighted sets of effect sizes was .966. A nonparametric estimate of the effect size, i.e., the median effect size, was also computed within each independent/dependent variable category. Once again the correlations with the other two weighting systems were in the high nineties. Since the alternative weighting systems all yielded the same results, it was decided to utilize the more statistically defensible system of weighting by the n size.

Before pooling study effect sizes, in order to arrive at a weighted average effect size for each independent/dependent variable category, it is important to determine whether the estimates of effect sizes from each study are reasonably consistent with the model of a single underlying population correlation for a given category (Hedges & Olkin, 1985). The test of the hypothesis of homogeneity of the population correlations, within say the k th independent/dependent category, would be as follows:

$$Q_k = \sum_{i=1}^p (n_i - 3) (z_i - \bar{z}_k)^2 \quad (2)$$

where \bar{z} is the weighted average given in (1) above and Q follows the chi-square distribution with $p-1$ degrees of freedom.

If Q exceeds the tabled chi-square, we are less confident that the weighted average is a good estimate of the population value for that independent/dependent variable category. This test is often disregarded in most meta-analysis, since it can be overly sensitive to small variations when the study sample sizes are relatively large. From our viewpoint it provides some added evidence for or against the reasonableness of the present categorization.

In order to test the statistical significance of the weighted averages, the Fisher Z 's for each study within a category are transformed back to product-moment correlations and then transformed to Student's " t ". The following algorithm, originally given by Wallace (1959) and suggested by Mullen & Rosenthal (1985), is used to transform t to Z , the standard normal deviate or Z -score.

$$Z = (df(\ln(1+t^2/df)))^{1/2} (1-(1/(2df)))^{1/2} \quad (3)$$

The combined significance test for weighted Z 's is obtained as follows:

$$Z_w = \frac{\sum_{i=1}^p n_i Z_i}{(\sum_{i=1}^p n_i^2)^{1/2}} \quad (4)$$

and the probability associated with Z is obtained using an algorithm originally suggested by Abramowitz & Stegun (1964) and reported in Mullen & Rosenthal (1985) as:

$$p = .5(1 + .049867347Z + .0211410061Z^2 + .0032776263Z^3 + .0000380036Z^4 + .0000488906Z^5 + .000005383Z^6)^{-16}$$

Given the possibility that significant studies may be more likely to be reported than nonsignificant studies, it is of interest to inquire how many nonsignificant studies would have to be added to change the conclusions.

This formula calculates the so-called fail-safe N (Rosenthal, 1984) as follows:

$${}_k N_{FS} = \frac{\sum_{i=1}^P Z_i}{1.645} - N_k \quad (5)$$

where N_k = number of studies in the Kth category and ${}_k N_{FS}$ = number of non-significant studies that would need to be added to change the conclusion for category k.

RESULTS AND DISCUSSION

Description of Study Characteristics and Relation to Effect Size Estimates

For the total available sample of study findings, from which a one-degree of freedom effect size--could be computed as a point-biserial r ($N = 211$), an overall mean effect size of .42 was found ($SD = .43$; with a range of effect sizes from -.48 to .99, indicating a distribution of considerable variability). The subject samples used in most of the studies were composed of nonmilitary personnel (76%), most of whom were college students. The studies were most likely to be conducted in a laboratory (79%), as opposed to field or operational settings. Ratings on the five-point scale of the three dimensions of study quality were: (a) Substantive Interest, $Mn = 3.2$; (b) Design/Methodology, $Mn = 2.7$; and (c) Reporting of Data, $Mn = 2.7$. Thus, while most of the studies could pose significant and cogent issues for research in the field, execution of a majority of them was, at best, below mediocre with regard to an appropriate (or understandable) study design and the reporting of quantitative results (particularly in

regard to meeting the minimal data requirements for the conduct of meta-analyses).

The mean size of the group constituting a team was 3.2 members, thus falling well within the small-group team intent for the literature obtained while the average size of the total sample for a given study (df in the denominator) was an N of 39. Exactly 50% of the 211 one-degree-of-freedom effect-size estimates available for analysis came from studies published in archival form (largely referenced journal articles), the other half being technical papers, theses or dissertations and paper presentations at professional meetings.

The relationships of study characteristics to effect-size magnitudes reveal a number of ways in which the studies of a particular type might have served to influence the effects obtained. As examples, it is found (gratifyingly) that the studies of higher rated quality tended to be the ones with the larger mean effect sizes (r 's for each of the three quality dimensions and effect size range from .21 to .24; $p < .01$). Type of experimental setting (laboratory vs. field) bears a relationship to mean effect size; the laboratory setting tended to produce larger effect sizes than the field studies ($r = .19$; $p < .01$). There was also a tendency, not too surprising in view of the two previous findings, to have low, but significant, relationships between the three quality ratings and laboratory vs. field studies (r 's = .21, .15 and .15; $p < .05$); such that lab studies produced the higher quality ratings. Of interest, among the relationships between study characteristics and effect size, are the variables of team size and total sample size utilized for the study. Both produced negative correlations (r 's = -.10 and -.22, $p < .01$) indicating that studies with

smaller size teams produced larger effect sizes, while studies of larger total sample size (i.e., number of df in the denominator) produced smaller mean effect sizes. There is also a tendency for more recent studies to produce larger effect sizes ($r = .15$; $p < .05$).

Some of the significant relationships between study characteristics are also worth noting. First, the three quality ratings variables are moderately related and can be said to reflect a degree of rater ability to differentiate between the dimensions as separate measures, rather than indicating an overly large halo effect. This is seen in the matrix of r 's below:

	(1)	(2)	(3)
	<u>Substantive Interest</u>	<u>Design Quality</u>	<u>Report of Data</u>
(1)	--	.52	.48
(2)		--	.65
(3)			--

Second, journal articles were more likely to have a higher level of data reporting quality--as might be expected. Third, studies of higher substantive interest were more likely to be conducted with smaller size teams and smaller total sample sizes. And fourth, field studies tended to use larger size teams and were especially likely to use larger sample sizes for study purposes.

In addition to the purely descriptive set of univariate r 's discussed above, a step-wise multiple regression analysis was undertaken to determine those study characteristics that jointly serve as the most important predictors of effect size. Three such study variables contributed significantly to a resulting R of .34. The one with the largest contribution

was found to be the type of experiment (as laboratory vs. field)--laboratory studies having been seen in the univariate analysis to produce larger effect sizes. The second variable was study quality based on the Substantive Interest of the research topic of inquiry; the third was the rating on quality of data reporting.

Overall Effects for Cross-Linked Variables

From the 12 dependent and 25 independent variable categories definable from the studies available in the data base, there were 115 resulting cross-classifications of those two sets of variables for which one or more effect size was available--i.e., as focused statistical tests or single degree of freedom contrasts.⁹ Where multiple findings existed for the same sample in a study, as previously discussed, the effect-size estimate was based on an average of those findings, so that no single sample contributed more than one finding to effect size estimates of any cross-classification category.

Both as a conservative approach to the interpretation or application of the meta-analysis results and, more pointedly, to permit testing for effect size homogeneity, it was necessary to set a criterion of two or more independent studies for inclusion in any cross-classifications of the variables on which the overall quantitative analysis summary is based (Table 1). The associated variables (dependent-independent variable linkages) are grouped by dependent-variable categories, showing their mean effect sizes, number of articles (independent studies) that entered into each mean effect-size estimate, "p" values, the standard normal deviate or Z

⁹Eta's were calculated from studies with multiple degrees of freedom in the numerator. They are presented in the data set--both for user information and in the event that suitable analytical techniques become available for dealing with such results in the future.

statistic, and the chi-square value indicative of effect size homogeneity. It is these cross-classified variables and their relative hierarchical value that represent the basic content of an empirically derived (i.e., literature-based) taxonomic system.

In Table 1, it can be seen that the predominant team performance outcome measures (based on frequency of links to independent variables and number of studies contributing to effect size estimates) consist of Accuracy of team task performance, Time required to achieve task solution and the Quantity of team product output. The remaining dependent task-output measure, overall team Proficiency, would appear close in concept to the Accuracy of outcome measure, and both might be considered representative of a broader dimension of team performance "quality"; whereas Time and Quantity, as dependent variables, could be said to represent a dimension of team "production" in performance output. Cohesiveness, Coordination and Interaction/Communication, that appear as dependent variables in this system, represent a set of variables customarily viewed as "process" or "mediating" constructs in most theoretical models postulated by investigators in the field of team performance. However, these three are clearly seen here to be the predominant "non-task-oriented" intervening measures that have been applied in team research studies to serve solely as outcome or performance (dependent) measures--i.e., in studies in which they are not linked directly to task performance outcomes.

Generally, the values of the effect-size estimates shown for this set of small-group team performance studies, represent a fairly substantial degree of association between team-member characteristics, interpersonal relations

Table 1

Results of Meta-Analysis for Cross-classification of
Independent/Dependent Variables of Team Performance Weighted by Sample Size
(Contribution of Two or More Studies to Mean Effect Size)

Cross Classification	Mean Effect Size	Number of Articles	p (one tail)	Fail Safe N^1	Z	Effect Size Homogeneity (Chi-square)
Accuracy and						
Prior Task Experience	.28	7	<.01	45	3.22	12.79*
Aptitude/Academic Ability	.14	4	.10	5	1.29	5.63
Task Complexity	.38	4	<.01	8	3.04	1.35
Task Load	.50	8	<.01	105	4.70	38.45*
Task Structure	.34	2	.02	2	2.06	.14
Coordination	.48	3	<.01	6	3.49	2.13
Interaction/Communication	.31	7	<.01	26	3.08	3.36
Length of Team Association	.28	2	.01	7	2.51	3.52
Performance Over Time (Practice)	.53	2	.02	5	2.14	8.55*
Solution Time and						
Prior Task Experience	.27	4	<.01	28	4.83	4.30
Task Complexity	.28	5	<.01	48	3.72	17.88*
Task Structure	.37	4	.01	12	2.51	18.90*
Cooperation/Competition	.56	2	<.01	11	3.82	1.11
Individual vs. Team	.48	4	<.01	42	5.21	4.10
Coordination	.15	3	.01	6	2.56	2.64
Interaction/Communication	.47	3	<.01	20	5.55	9.22*
Feedback/FR	.25	2	.03	1	1.82	.28
Product Quantity and						
Aptitude/Ability	.27	2	.01	1	2.48	3.03
Motivation	.34	2	.03	2	1.92	.95
Task Complexity	.78	4	<.01	67	7.73	16.31*
Task Load	.54	3	.01	14	2.49	16.79*
Task Structure	.65	4	<.01	28	4.65	13.58*
Cohesiveness	.26	9	<.01	115	6.20	40.09*
Coordination	.31	4	.01	4	2.52	1.81
Member Homogeneity	.12	3	.05	3	1.67	4.69
Performance Over Time (Practice)	.77	3	<.01	19	3.93	14.32*
Supervision/Leadership	-.05	2	.27	--	.61	.25

¹Based on unweighted sample sizes.

*Chi-square significant at .01 level.

Table 1 (continued)

Results of Meta-Analysis for Cross-classification of
Independent/Dependent Variables of Team Performance Weighted by Sample Size
(Contribution of Two or More Studies to Mean Effect Size)

Cross Classification	Mean Effect Size	Number of Articles	p (one tail)	Fail Safe N^1	Z	Effect Size Homogeneity (Chi-square)
Cohesiveness and Size	.17	2	.08	--	1.40	.47
Aptitude/Ability	.33	3	<.01	10	4.59	3.88*
Cooperation/Competition	.54	2	<.01	9	3.80	.10
Coordination	.14	2	.11	--	1.22	.58
Member Homogeneity	.12	2	.03	3	1.90	1.74
Coordination and Task Fidelity	.40	2	<.01	4	2.78	.04
Cooperation/Competition	.42	2	<.01	4	2.65	.19
Coordination	.22	2	.03	1	1.95	.22
Interaction/Communication and Task Load	.30	2	.01	2	2.34	.10
Feedback (KR)	.40	2	<.01	4	2.86	.13
Performance Over Time (Practice)	.67	2	<.01	11	4.02	.29
Trials to Acquisition or Extinction and Prior Experience	.34	2	.08	--	1.37	.39
Overall Task Proficiency and Aptitude/Academic Ability	.12	3	.01	6	2.54	2.12
Task Complexity	.27	2	.04	3	1.76	7.44*
Task Structure	.23	2	.03	1	1.95	.00
Cohesiveness	.31	2	<.01	10	3.62	1.33
Coordination	.08	2	.26	--	.66	1.94
Interaction Communication	.48	2	.02	2	2.17	.19

¹Based on unweighted sample sizes.

*Chi-square significant at .01 level.

and task conditions and the various team outcome variables listed.¹⁰ The range of r 's from about .10 to the mid .70's, with a large proportion of the estimates clustered in the .30 to .50 range, must be considered impressive comparisons in contrast to magnitudes of relationships generally found in behavioral and social sciences. For the most part, these results would rank as "medium" to "large" effect sizes under Cohen's (1977) criteria and rationale for defining the value of different effect size magnitudes. That is, team performance, as representative of an area within the field of Social Psychology, would be viewed as an area in which measurement validity and experimental control are often less than optimum (i.e., "weak"); so that in relation to results achieved in that field and similar fields, Cohen's interpretive ratings would treat an r of .10 as "small" in effect size, $r = .30$ as "medium," and $r = .50$ as a "large" magnitude of effect. Interpretation of many of the larger effect sizes must, however, be tempered with caution by virtue of their tendency to show significant heterogeneity of study findings. For example, the .77 effect size for the Quantity and Task Complexity linkage and the equally large magnitude of .78 for Quantity and Practice are the result of widely disparate, heterogeneous, study findings (e.g., the mean effect size estimate for the Quantity and Task Complexity linkage category was based on four individual effect sizes that range from a low of .26 to a high of .94). Somewhat more confidence in the interpretation of mean effect sizes can be placed in those values which may not be quite as large, but which show markedly greater homogeneity, or consistency, from

¹⁰All r 's are shown as positive when in the hypothesized or predicted direction. Note, that all significant mean effect sizes are found to reflect a positive direction for the independent variable under study (although negative r 's were present for individual study findings).

study to study (as well as those based on a larger number of articles comprising the mean r obtained).

Given such guidelines, there are patterns of linkages that can be highlighted from the results in table 1. For team performance quality in the form of accuracy, positive and reliable effect sizes of medium magnitude are found with the two independent variables of prior team member experience, (length of team member association with one another, and amount of previous experience in the specific team task), while larger and more homogeneous effect sizes are found for associations with Interaction/Communication, Task Complexity, Task Load, Task Structure, and Member Coordination. Measured aptitudes and abilities of individual team members are found to produce only small effects on the quality of team output.

A number of these independent variables show similarly moderate to large effect-size links to the two dependent variables that comprise a productivity dimension (i.e., Time to perform and product Quantity). Thus, Task Complexity, Load, Structure and Interaction/Communication provide some of the largest effect-size magnitudes for the two productivity outcomes. But it can be noted that, among the linkages for those two outcome variables, there is generally greater heterogeneity (less consistency) underlying the magnitudes of the findings that make up their mean effect sizes than was found for the quality dimension. (This finding is somewhat at odds with what would be expected, since measurement of Time and Quantity of performance should be more "objectively" similar and of greater validity as outcome measures, from study to study, than are Accuracy and Overall Proficiency.) The two team characteristics of a more "interpersonal" orientation that stand out, by virtue of their medium-to-large linkages with task performance, are

Motivation and Cooperation/Competition which are associated with the two productivity variables of performance Time and Quantity. Interestingly, in the instance where a linkage category exists for Supervision/Leadership (i.e., with product Quantity), its effect size proves to be nil.¹¹

The three constructs, customarily conceived of as intervening or process measures--but appearing in the team literature incorporated here as dependent outcome measures--produce a pattern of association that is clearly similar for two of them (Cohesiveness and Coordination) and dissimilar for the third (Interaction/Communication). That is, Cohesiveness and Coordination as dependent variables show links with independent variables which can be said to reflect member personal characteristics (e.g., Aptitude, Cooperation/Competition), whereas studies dealing with Interaction/Communication as the dependent variable produce linkages and effect-size magnitudes with variables that reflect team task-oriented dimensions (Quality, Productivity, and Practice).

Based on overall consideration of the number, magnitude, pattern and homogeneity of effect-sizes that produced the dependent-independent variable linkages in Table 1, a somewhat coarse, but reasonable, hierarchy of seven most explanatory independent variables could be defined in order of relative importance, or ranking, as follows: (1) Task Complexity, (2) Task Structure, (3) Performance Over Time (practice), (4) Interaction/ Communication, (5) Task Load, (6) Cooperation/Competition, and (7) Coordination. Other

¹¹The result may be attributable to a relative sparsity of leadership studies conducted in a team context. Those studies tended to be more prevalent in an earlier period than the one covered by this meta-analysis (i.e., in the 1940's and 1950's).

variables of less frequent occurrence and of lesser effect size--e.g., Prior Task Experience, Aptitude and Ability, Feedback and Cohesiveness--make sufficiently lesser contributions to the cross-classification system, generally, to warrant remaining unranked and considered similar in their hierarchical value.

Training-Oriented Linkages

In view of the widespread interest in team training expressed in the narrative literature reviews, it would be of value to comment on results obtained specifically for that set of linkages that can be construed as involving team training independent variables--i.e., Prior Task Experience, Practice and Feedback/KR. The three, as a composite, are seen to produce medium to large effect-size magnitudes within the cross-classification system. Thus, there are uniformly medium effect sizes attributable to Prior Task Experience that occur in relation to Accuracy and Time as performance outcomes, as well as to the highly specific learning outcome of Trials to Acquisition or Extinction.¹² As might be expected, Practice shows the strongest links to either a production (Quantity) or Quality (Accuracy) type of team performance outcome measure (r 's = .50 and .77, respectively) as well as to the mediating variable of Interaction/Communication. Feedback/KR proves to be the least extensive in its presence, but shows moderate effect sizes in associations with solution Time and Interaction/Communication.

¹²If Length of Team Member Association is viewed as an independent variable having somewhat similar implications for training as the variable of Task Experience, then the uniformity of the medium effect size (approximately .30) is further strengthened for this set of training-oriented linkages.

This pattern of effect sizes for learning-related experimental variables suggests possible priorities and potential value for future application in training research settings. For example, the fact that practice proves to be of considerable value seems reasonably well demonstrated--both here and in learning research studies in general. But greater research emphasis on the performance effects associated with feedback would appear to be warranted over a broader range of outcome variables than has been attempted, thus far, in the team performance literature.

Effect Size Estimates, Model Building and Research Gaps

The logic of an organizing system that classifies dependent and independent team performance variables can be taken a step beyond simple description and hierarchical ordering to a level that suggests potential explanatory effects. By using the quantitative evidence from the literature in the form of effect size estimates, it is possible to construct hypothetical models based on the variable linkages obtained. Specifically, the variables uncovered in the cross-classification system that are generally conceived of as process or intervening measures (i.e., Coordination, Cohesiveness, Interaction/Communication) can be incorporated in a model so as to "mediate" between exogenous (input) variables and output variables--i.e., in a path or causal-model format, using available effect size estimates as the values to define the interdependencies. Although such values are not substitutes for standardized path coefficients, they provide an opportunity to consider whether the zero-order effect sizes uncovered are consistent with

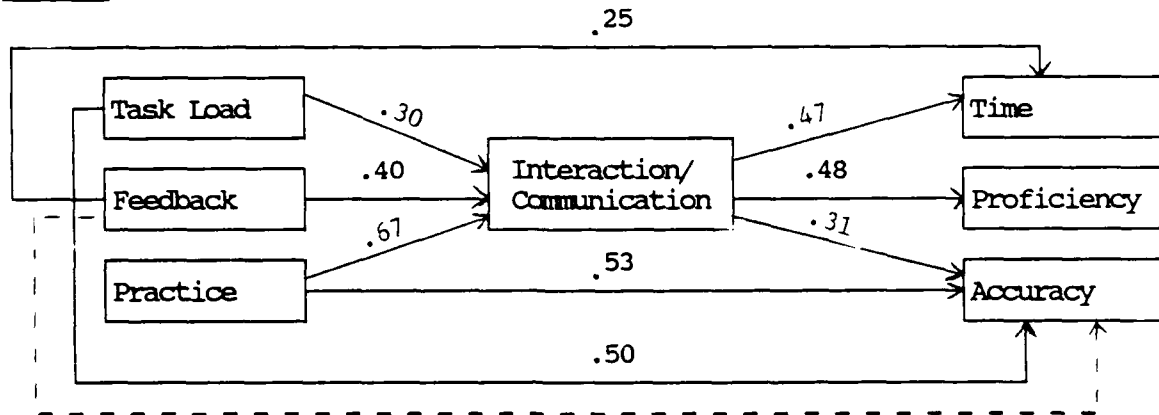
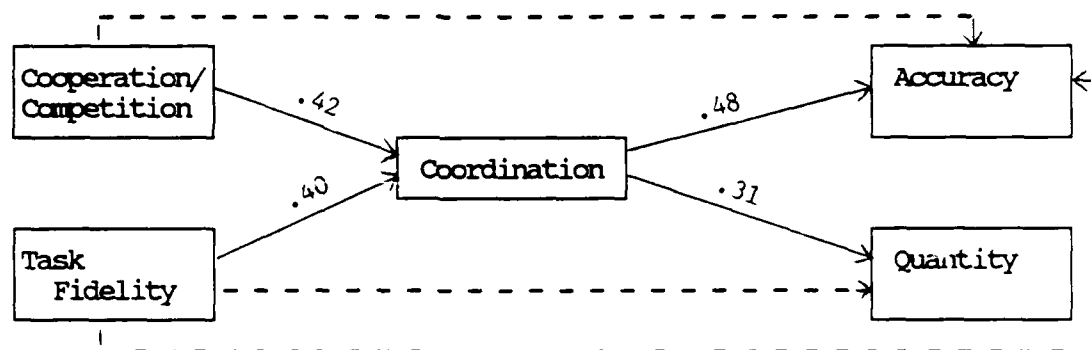
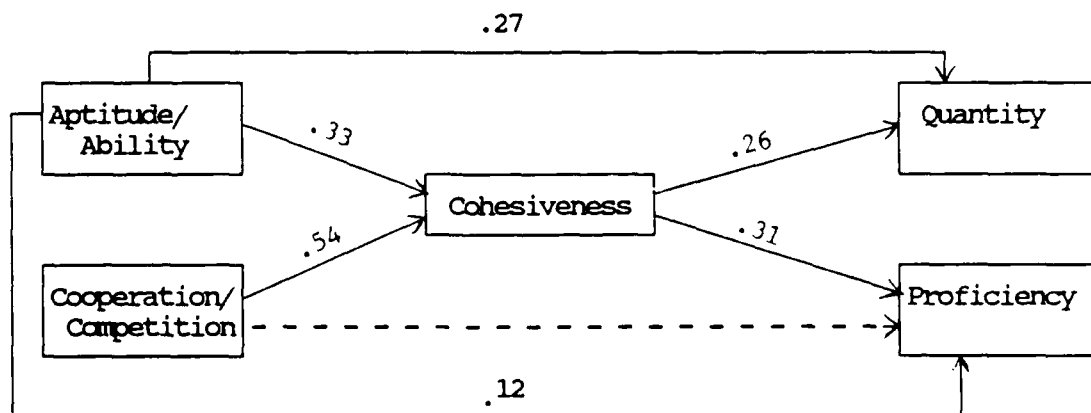
any given model that hypothesizes (or computes) path coefficients linking the same or similar variables.¹³

The form and content of the models presented below will be seen to follow directly from the cross-classification system of variable linkages uncovered in the meta-analysis. Consider Model I (Figure 1). Based on Interaction/Communication as the mediating variable, a "mini" (small-scale) model emerges that is almost completely specified from the linkages available. Those input and output measures that enter into the model, are based on their having mean effect size linkages with the mediating variable definable as approximately "medium" or greater in magnitude. The input variables of Task Load, Feedback and Practice are seen as the ones that qualify, by virtue of having uniformly substantial links to Interaction/Communication. That mediating construct, in turn, has significant associations with both production and quality measures of team output (Time, Accuracy and Proficiency). Task Load and Practice not only could be said to act through Interaction/Communication as the mediator, but are seen to produce even stronger direct effects on Accuracy of output. Feedback, by contrast, appears to exercise a greater role on performance outcomes through the mediation of Interaction/Communication, with only a modest direct link to Time as a performance outcome.

¹³A reduction in the magnitudes of these coefficients (effect size estimates) would be likely in any conventionally-derived structural-causal system, since there would be some degree of intercorrelation between the explanatory variables. However, although they represent biased upper estimates--in comparison to standardized partial regression weights (path coefficients)--having significant effect sizes (r 's) is a necessary, if not sufficient condition, for observing a significant path coefficient. The effect sizes can be viewed as similar to those coefficients in the relative ranking of their magnitudes.

Figure 1

Mini-models Based on Effect Size Contribution to Variable Linkages

MODEL IMODEL IIMODEL III

The significant role of communication, as a process variable, ranks among those generally "recognized as important" (from the literature) in its relationships to other variables throughout the life cycles of teams. It appears as one in the list of process variables, found in the all-inclusive "Team Training and Performance" model of Morgan et al. (1986), that is acted upon by "Team Functions" while acting, in turn, upon outcomes. However, the focus or degree of the hypothesized influence of the variable--as in most such assumed models--remains essentially unspecified. By contrast, the important antecedent conditions in the present model (Model I) indicate that the mediating influences of communication are likely to manifest themselves as a result of the effects of three heavily task-dependent team conditions involving Load, Feedback and Practice--with the latter two as primary.

Major gaps in the available research that should be filled, for more complete specification of any model, also become apparent in this modeling approach involving the use of effect size linkages from the cross-classification system. Such needs for more complete information regarding relationships between important variables, as suggestive of future research emphases, are illustrated in Model I (and the two subsequent models) by use of the dashed line. Here the research gap indicated is that of a lack of adequate information to establish an hypothesized link between Feedback and performance Accuracy.¹⁴ Another identifiable direct link in Model I, that remains unspecified, is the one between Task Load and performance Time. It

¹⁴Studies exist in the available data base that purport to demonstrate such a relationship, but the information presented was not adequate for computation of a mean effect size estimate based on the inclusion criteria previously specified.

is not cited as a fruitful research priority (and is not likely to constitute a study area of choice for investigators), since it is virtually a "generic" finding in all learning studies that increasing Task Load increases performance Time. For a similar reason, the need for additional research to establish a direct link between Practice and team performance Time could be considered a research issue that warrants a low priority as an addition to the current model.

Model II of Figure 1 illustrates the mini-model that results from using Coordination as a process variable. This mediator is one that has almost universally been incorporated in the variable listings of many models diagrammed in the team literature and one that has been emphasized as being fundamental to any generalized theories of team and group performance in work settings (Von de Ven, Delberg & Koenig, 1976). For Alexander and Cooperman (1976) the construct is considered central to one of their two basic models of task-oriented teams--i.e., the "organismic model." In addition, it has been the focus of a research effort to quantify its influence based on the development of a path model of team performance by Daley (1980), in which Coordination is viewed as an "integrating" mechanism for task group activity. Model II is much less completely specified than was Model I, based on available effect-size estimates from the meta-analysis. Here, it is evident that Cooperation/Competition in the team setting and Task Fidelity (as inputs), have links to the Coordination process variable which, in turn, shows strong effect size linkages (i.e., r 's = .48 and .31) to outputs of performance Quantity and Accuracy. A similar level of relationship between coordination and performance outcome is found in Daley's (1984) causal model.

in the form of a significant zero-order r of .35 and a strong path coefficient linkage in its effect on a team performance outcome measure of quality. Cooperation/ Competition and Task Fidelity represent exogeneous variables in Model II, not specifically considered in Daley's structural model, so no specific quantitative match is feasible against the present results.

Several major gaps, representing an insufficient amount of research to support specific variable linkages are apparent, if the explanatory value of Model II is to be improved. One is the need to define the effect of the independent variable of Cooperation/Competition directly on output Accuracy. The issue is one of whether Cooperation/Competition exercises its effects primarily through variations in the amount of team coordination achieved or is linked as strongly (if not more strongly) in some direct way to team quality of output. No pressing research need is seen to be indicated for the link between Cooperation/Competition and Product Quantity (which lacks the dashed connecting line), since there is already evidence in this cross-classification system of a large link between Cooperation/Competition and the output variable of performance Time (i.e., an effect size of .56 found in Table 1). Certainly, these results raise the distinct prospect that Cooperation/Competition could prove to be a major influence on team output, both in its direct effects as well as through mediating processes in the team setting. The model also serves to illustrate the potential value of studying task Fidelity--an independent variable that does not tend to be incorporated

in conventional models. The void to be filled for the measure concerns its association with the team performance outcomes of Accuracy and Quantity.¹⁵

Model III indicates that Cooperation/Competition is further enhanced in its general importance as an independent variable by virtue of its magnitude of linkage to the process variable of team Cohesiveness--and its apparent indirect effects on team production (Quantity) and quality (Proficiency). Its effect size proves to be relatively large in its association with that mediator, through which it shows moderate effects on team outcome proficiency. The research gap to be filled here remains (as in Model II) one of defining the strength of the direct link between Cooperation/Competition and team performance quality. The presence of Aptitude/Ability in Model III represents the one independent variable of member "personal" characteristics that is found in any of the three definable mini-models--in contrast to team task characteristics that have obviously predominated. It is of interest that this input measure represents at least as much of an influence on team performance output, through Cohesiveness as a mediating variable, as it does in its direct links. The significance of the Cohesiveness team performance (Proficiency) link seen in Model III (.31), is confirmed in Daley's (1984) causal model even more strongly (i.e., by a zero-order r of .55 and a large path coefficient). Its key role in that path model indicates that cohesiveness not only acts directly upon performance outcome, but also shows a modest indirect influence on performance by acting through the other

¹⁵Interestingly, there are scattered findings that exist in the data base (but not sufficient to meet the minimum meta-analysis statistical inclusion criteria) to obtain some clue as to the Fidelity-task performance linkage. These indicate uniformly low and nonsignificant effects (Vote = 0) on several performance outcomes. Thus, future research might be expected to confirm that task fidelity acts primarily through member coordination to influence outcome.

mediating variable of Coordination. It is also notable that the small effect size of .14, found in the present cross-classification system of Table 1 between the mediating variables of Cohesiveness and Coordination, is directly comparable to Daley's zero-order r of .18 obtained for those variables as used in his path model.

Such comparable results suggest that the present meta-analytically based modeling approach can provide support for a causal (path) model, defined by structural analytic techniques. But, it is equally suggestive of the prospects that could be realized by incorporating additional research findings in the present cross-classification system of variables, so as to permit the weaving of a "lattice-work" that connects these mini-models into broader explanatory structures. For example, since Models II and III possess two process variables of known linkage value across the models (i.e., Coordination and Cohesiveness), as well as a common independent variable (Cooperation/Competition), it appears that filling in a number of the missing variable links, pinpointed as future research priorities (primarily the direct input-output links), could yield a larger model that is reasonably well specified and more comprehensive. Such empirically-based models, derived from structural-causal analyses and from meta-analytically derived networks of associated variables, can be used to complement one another for more precise understanding and control of variables that influence team processes.

SUMMARY AND CONCLUSIONS

The present study has demonstrated a generalizable approach to the development of a functional classification system ("taxonomy") that could improve the understanding of ways in which small-group team characteristics

serve to influence performance outcomes. By use of meta-analysis to summarize research findings it has been possible to: (a) identify a domain of empirically defensible study variables embedded in a coherent structure of variable associations or linkages, (b) define the relative value of those variables in terms of their explanatory role in a classification system, (c) point to fruitful research directions by identifying variable linkages that remain to be specified and tested in the system, and (d) construct a flexible public-use data set, designed to permit both additional analyses tailored to individual information needs and the incorporation of new research information.

With meta-analysis as the vehicle for integrating the team performance research literature, effect-size estimates were obtained for 46 cross-classification categories of dependent and independent variables that met the criteria for incorporation in this system of quantified variable linkages. The technique also permitted identification of characteristics of studies that can have an important influence on the results obtained. Thus, there were significant relationships found between rated study quality and effect-size magnitudes, such that larger effect sizes were significantly more likely to be found in better quality studies--i.e., those that investigated problems of more substantive value, with better research design or methodology and better reporting of data. There was also a greater likelihood that studies conducted in laboratory settings, as opposed to field settings, would produce larger effect sizes, as would those conducted with smaller size teams. It seems logical that these findings are due to the fact that better control of the study conditions or variables, as well as the organization of team participants, is possible in the laboratory--i.e., there

are fewer logistical and methodological problems in the laboratory than in the field, and with smaller than with larger teams. It should be kept in mind that laboratory studies had significantly larger effect sizes even after controlling for substantive quality. This suggests that the larger effect sizes from the laboratory studies were testing more than trivial hypotheses. But, it is also important to note that any superiority of findings from the laboratory versus the field setting is most likely based on an aggregate of studies having a different mix of experimental and outcome variables applied under the two settings. A more valid contrast of the lab vs. field results would require that specific studies of similar design be undertaken in each setting with the same independent and dependent variables being assessed and based on use of the same or similar measurement tools. The long-term controversy that has been concerned with task fidelity and its relationships to validity and generalizability of findings from laboratory studies of teams (i.e., their relevance to the "practical realities" of operational settings) would still require such evidence for reasonable resolution of the issues involved.

Independent measures of team task characteristics, such as complexity and structure, as well as those variables generally considered to be process or mediating variables (i.e., Coordination, Interaction/Communication and Cooperation/Competition) were found to rank at the top of a hierarchy of cross-classified variables in this system as defined by both consistency and magnitude of effect size. In addition, among several categories of independent variables that have direct implications for team training (i.e., prior task experience, practice and feedback/KR), there are uniformly medium effect-size contributions to team performance output--primarily in

terms of performance accuracy and time. Training benefits to be gained for the team as an entity by proper utilization of conditions of task experience and performance feedback have also appeared as important in the literature for military crews in a variety of settings--as discussed by Dyer (1984) in her narrative review. However, it was possible with the present data to go beyond general inductive inferences about the effects of these and other variables to their quantitative role in a larger team performance framework, within a structured classification system.

Use of the magnitudes of effect size estimates to define the degree of input, process and output variable associations, permitted the construction of a set of "mini" models, in a causal format, that serves to summarize possible explanatory influences of the general categories of variables. The relational links, that logically follow from the effect-size data, determined the structure of the models defined. From these, a number of team input variables (e.g., Task Load, Practice, Feedback, and Cooperation/Competition) are suggested as linked to team output through their "indirect" association with the mediating (process) variables of Interaction/Communication, Coordination and Cohesiveness. For example, in one model, Feedback as an independent variable was found to possess a strong link with Interaction/Communication which, in turn, was linked in other studies to several performance outcomes--the presumption being that in a causal system, knowledge of results is likely to exercise at least some of its major effects through the patterns of member communication established within the team. For other independent variables in that model (Task Load and Practice), there was also a presumption of strong indirect effects acting through the mediating communication variable, while equally strong direct effects were

found for those independent variables on output measures of team performance "quality" (Proficiency and Accuracy). The two other models that emerged from the data were used, in a similar way, to define potential input-process-output linkages. Research gaps become evident when the models are depicted in this manner, in that direct links for demonstrating the degree of direct effect of a number of the experimental variables on major outcomes are found lacking (or insufficient) in the literature to permit their specification in the meta-analysis (e.g., independent variables of Feedback, Cooperation/Competition and Task Fidelity). Remedying the research deficiencies would serve to specify more fully and formally test the influences of such variables in the model.

Presentation of the meta-analytically derived variable linkages in the format of these small-scale causal models provides some understanding of the relative importance of specific study variables in a more macro framework, as well as a quantitative estimate of their potential degree of influence at a fairly simplified but manageable level. However, the forms of research evidence needed to combine the models into broader explanatory networks (available from the meta-analysis results or on the basis of additional research findings) also become more evident from examination of the particular variables present in each model and the magnitudes of effect size. Further, by organizing the variables into a coherent cross-classification system and incorporating them in a computer-based management information system (i.e., in a spreadsheet format for use with a personal computer), a framework is provided within which additional quantitative research results can be incorporated, so as to refine, modify, or (where necessary)

restructure the system of variable linkages, in order to build additional miniature models or larger networks of combined models.

Appropriate additional research, for bolstering the meta-analysis information data base utilized in the present study, will not be easy to acquire. By any set of research standards, studies utilizing small groups functioning as teams require solution of a myriad of unique and difficult problems in their planning, organization and conduct--whether in a field or laboratory setting. These include obtaining adequate sample size, where the team constitutes the unit of measurement, and the control of specific study variables where teams of defined characteristics must be organized to carry out relatively complex interacting tasks in specified ways. But, granted any number of inherent logistical, methodological and analytical drawbacks, there have been glaring deficiencies in the team performance literature. Primary among the deficiencies has been the definitional problem, that entails distinguishing team research from the vast, largely unrelated, studies dealing with task-performing groups in general. For researchers, theorists and reviewers, inconsistent applications of the team designation continue to muddy the conceptual waters by providing misleading information that adds to the already considerable efforts required for study identification, acquisition, interpretation of findings and formulation of useful models (as has often been evident in conventional, discursive reviews and hypothesized models). Another frustrating aspect of utilizing the literature--and one that should be attended to in planning future research efforts--revolves around the quality of study reporting, especially in regard to sufficient explanations of study design, reporting of analyses undertaken and summarizing of results from the data analyses. Such deficiencies, that can

seriously impede attempts at quantitative-integrative reviews, have proven to be characteristic of a large proportion of technical reports on team performance, many of which presented valuable hypotheses and study purposes--and in many instances carried out their intentions at considerable expense and effort--but failed to report sufficient detail regarding the conduct of the effort or the quantitative results achieved. More rigorous efforts at "methodological quality control" would appear to be in order here, as has been suggested for other areas of psychological research (Sechrest, 1986). The critical need is to move team research forward in a way that prevents further fragmentation of the field, by drawing upon more coherent and organized bases of knowledge for teams as distinct entities, while stressing adherence to better study design and reporting standards.

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APPENDICES

Appendix A: Code Sheet

Appendix B: Code Designations for Dependent and
Independent Variables

Appendix C: Lotus Spreadsheet Headings for 25 Fields
by Field Letter Designation

Appendix D: Studies in Data Base From Which Quantitative
Findings Were Obtained for Meta-Analysis

Appendix E: Team Performance Data Base Disk

APPENDIX A

CODE SHEET

GROUP COMPOSITION

IDENTIFICATION

1. Study ID #: 3025
2. Coder ID #: Rock (2)
3. Source of Study:

(1) <u> </u> Book	(4) <u> </u> Dissertation (complete Item 4)
(2) <u>x</u> Journal (complete Item 4)	(5) <u> </u> Paper Presentation
(3) <u> </u> Technical Paper	(6) <u> </u> Unpublished Manuscript
	(7) <u> </u> Other
4. Paper or journal type: 1 (APA = 1; non-APA = 0)
Complete this item if 3(2) or 3(5) above is checked.
5. Type of study subject personnel: 1 (military = 0; non-military = 1;
2 = both)
6. Year study was published: 76
7. Substantive Interest (1 to 5) 5
Relationships between group ability, shared values, group
performance and group cohesion is a very important area.

8. Design/Methodology (1 to 5) 4
Authors used a 2 (ability) x 2 (similarity of values) x 6
(separate projects) design with repeated measures on 6
projects - good design.

9. Reporting Data (1 to 5) 5

10. Were intercorrelations reported between dependent variables

 No

 x Yes Correlations were computed between performance
(Describe)
and cohesion within each of the six projects. One of the six
was significant and it was negative. No Interpretation
was made.

11. Overall Comments

Good article - well designed - well-written
and included important independent variables.

[illegible]

<u>Independent Variable</u>	<u>Dependent Variable</u>	<u>Outcome</u>
1. Age	2. Gender	3. Education
4. Income	5. Employment	6. Health
7. Social Network	8. Coping Mechanisms	9. Resilience
10. Life Events	11. Stress Levels	12. Mental Health
13. Family Support	14. Community Involvement	15. Life Satisfaction
16. Personal Growth	17. Self-Esteem	18. Overall Well-being

Higher Group

Ability-Greater

Accuracy

•

1

100

The more intrinsically

Interesting the projects.

the better the accuracy

(performance)

Interest

Legend

1. $\text{cor} = 5$; 2. $\text{cor} = 4$; 3. $\text{cor} = 3$; 4. $\text{cor} = 2$; 5. $\text{cor} = 1$; 6. $\text{cor} = 0$; 7. $\text{cor} = -1$; 8. $\text{cor} = -2$; 9. $\text{cor} = -3$; 10. $\text{cor} = -4$; 11. $\text{cor} = -5$; 12. $\text{cor} = -6$; 13. $\text{cor} = -7$; 14. $\text{cor} = -8$; 15. $\text{cor} = -9$; 16. $\text{cor} = -10$; 17. $\text{cor} = -11$; 18. $\text{cor} = -12$; 19. $\text{cor} = -13$; 20. $\text{cor} = -14$; 21. $\text{cor} = -15$; 22. $\text{cor} = -16$; 23. $\text{cor} = -17$; 24. $\text{cor} = -18$; 25. $\text{cor} = -19$; 26. $\text{cor} = -20$; 27. $\text{cor} = -21$; 28. $\text{cor} = -22$; 29. $\text{cor} = -23$; 30. $\text{cor} = -24$; 31. $\text{cor} = -25$; 32. $\text{cor} = -26$; 33. $\text{cor} = -27$; 34. $\text{cor} = -28$; 35. $\text{cor} = -29$; 36. $\text{cor} = -30$; 37. $\text{cor} = -31$; 38. $\text{cor} = -32$; 39. $\text{cor} = -33$; 40. $\text{cor} = -34$; 41. $\text{cor} = -35$; 42. $\text{cor} = -36$; 43. $\text{cor} = -37$; 44. $\text{cor} = -38$; 45. $\text{cor} = -39$; 46. $\text{cor} = -40$; 47. $\text{cor} = -41$; 48. $\text{cor} = -42$; 49. $\text{cor} = -43$; 50. $\text{cor} = -44$; 51. $\text{cor} = -45$; 52. $\text{cor} = -46$; 53. $\text{cor} = -47$; 54. $\text{cor} = -48$; 55. $\text{cor} = -49$; 56. $\text{cor} = -50$; 57. $\text{cor} = -51$; 58. $\text{cor} = -52$; 59. $\text{cor} = -53$; 60. $\text{cor} = -54$; 61. $\text{cor} = -55$; 62. $\text{cor} = -56$; 63. $\text{cor} = -57$; 64. $\text{cor} = -58$; 65. $\text{cor} = -59$; 66. $\text{cor} = -60$; 67. $\text{cor} = -61$; 68. $\text{cor} = -62$; 69. $\text{cor} = -63$; 70. $\text{cor} = -64$; 71. $\text{cor} = -65$; 72. $\text{cor} = -66$; 73. $\text{cor} = -67$; 74. $\text{cor} = -68$; 75. $\text{cor} = -69$; 76. $\text{cor} = -70$; 77. $\text{cor} = -71$; 78. $\text{cor} = -72$; 79. $\text{cor} = -73$; 80. $\text{cor} = -74$; 81. $\text{cor} = -75$; 82. $\text{cor} = -76$; 83. $\text{cor} = -77$; 84. $\text{cor} = -78$; 85. $\text{cor} = -79$; 86. $\text{cor} = -80$; 87. $\text{cor} = -81$; 88. $\text{cor} = -82$; 89. $\text{cor} = -83$; 90. $\text{cor} = -84$; 91. $\text{cor} = -85$; 92. $\text{cor} = -86$; 93. $\text{cor} = -87$; 94. $\text{cor} = -88$; 95. $\text{cor} = -89$; 96. $\text{cor} = -90$; 97. $\text{cor} = -91$; 98. $\text{cor} = -92$; 99. $\text{cor} = -93$; 100. $\text{cor} = -94$; 101. $\text{cor} = -95$; 102. $\text{cor} = -96$; 103. $\text{cor} = -97$; 104. $\text{cor} = -98$; 105. $\text{cor} = -99$; 106. $\text{cor} = -100$; 107. $\text{cor} = -101$; 108. $\text{cor} = -102$; 109. $\text{cor} = -103$; 110. $\text{cor} = -104$; 111. $\text{cor} = -105$; 112. $\text{cor} = -106$; 113. $\text{cor} = -107$; 114. $\text{cor} = -108$; 115. $\text{cor} = -109$; 116. $\text{cor} = -110$; 117. $\text{cor} = -111$; 118. $\text{cor} = -112$; 119. $\text{cor} = -113$; 120. $\text{cor} = -114$; 121. $\text{cor} = -115$; 122. $\text{cor} = -116$; 123. $\text{cor} = -117$; 124. $\text{cor} = -118$; 125. $\text{cor} = -119$; 126. $\text{cor} = -120$; 127. $\text{cor} = -121$; 128. $\text{cor} = -122$; 129. $\text{cor} = -123$; 130. $\text{cor} = -124$; 131. $\text{cor} = -125$; 132. $\text{cor} = -126$; 133. $\text{cor} = -127$; 134. $\text{cor} = -128$; 135. $\text{cor} = -129$; 136. $\text{cor} = -130$; 137. $\text{cor} = -131$; 138. $\text{cor} = -132$; 139. $\text{cor} = -133$; 140. $\text{cor} = -134$; 141. $\text{cor} = -135$; 142. $\text{cor} = -136$; 143. $\text{cor} = -137$; 144. $\text{cor} = -138$; 145. $\text{cor} = -139$; 146. $\text{cor} = -140$; 147. $\text{cor} = -141$; 148. $\text{cor} = -142$; 149. $\text{cor} = -143$; 150. $\text{cor} = -144$; 151. $\text{cor} = -145$; 152. $\text{cor} = -146$; 153. $\text{cor} = -147$; 154. $\text{cor} = -148$; 155. $\text{cor} = -149$; 156. $\text{cor} = -150$; 157. $\text{cor} = -151$; 158. $\text{cor} = -152$; 159. $\text{cor} = -153$; 160. $\text{cor} = -154$; 161. $\text{cor} = -155$; 162. $\text{cor} = -156$; 163. $\text{cor} = -157$; 164. $\text{cor} = -158$; 165. $\text{cor} = -159$; 166. $\text{cor} = -160$; 167. $\text{cor} = -161$; 168. $\text{cor} = -162$; 169. $\text{cor} = -163$; 170. $\text{cor} = -164$; 171. $\text{cor} = -165$; 172. $\text{cor} = -166$; 173. $\text{cor} = -167$; 174. $\text{cor} = -168$; 175. $\text{cor} = -169$; 176. $\text{cor} = -170$; 177. $\text{cor} = -171$; 178. $\text{cor} = -172$; 179. $\text{cor} = -173$; 180. $\text{cor} = -174$; 181. $\text{cor} = -175$; 182. $\text{cor} = -176$; 183. $\text{cor} = -177$; 184. $\text{cor} = -178$; 185. $\text{cor} = -179$; 186. $\text{cor} = -180$; 187. $\text{cor} = -181$; 188. $\text{cor} = -182$; 189. $\text{cor} = -183$; 190. $\text{cor} = -184$; 191. $\text{cor} = -185$; 192. $\text{cor} = -186$; 193. $\text{cor} = -187$; 194. $\text{cor} = -188$; 195. $\text{cor} = -189$; 196. $\text{cor} = -190$; 197. $\text{cor} = -191$; 198. $\text{cor} = -192$; 199. $\text{cor} = -193$; 200. $\text{cor} = -194$; 201. $\text{cor} = -195$; 202. $\text{cor} = -196$; 203. $\text{cor} = -197$; 204. $\text{cor} = -198$; 205. $\text{cor} = -199$; 206. $\text{cor} = -200$; 207. $\text{cor} = -201$; 208. $\text{cor} = -202$; 209. $\text{cor} = -203$; 210. $\text{cor} = -204$; 211. $\text{cor} = -205$; 212. $\text{cor} = -206$; 213. $\text{cor} = -207$; 214. $\text{cor} = -208$; 215. $\text{cor} = -209$; 216. $\text{cor} = -210$; 21

Interaction = 11; Simple main effects (Post Hoc Analyses) = 12; Other = 13

Note
0 = Not significant or favoring control
1 = significant finding favoring treatment

Group size-
When size varies leave
group size blank

Field vs. Lab

1. Field random assignment
2. Field nonrandom assignment
3. Lab random assignment
4. Lab nonrandom assignment

7a. Study Statistics

[illegible]

7a. Study Statistics

[illegible]

APPENDIX B

Code Designations for Dependent and Independent Variables (In Spreadsheet Data File)

Variable	Code #	Variable	Code #
<u>Dependent Variables</u>			
Accuracy	1	Cohesiveness	7
Time	2	Coordination	8
Quantity	3	Satisfaction	9
Task Transfer	4	Interaction/Communication	10
Solution Agreement	5	Trials to Acquisition	29
Originality	6	Overall Proficiency	31
<u>Independent Variables</u>			
Sex	11	Role Stratification	23
Team Size	12	Individual vs. Team	24
Prior Experience	13	Cohesiveness	25
Aptitude/Ability	14	Coordination	26
Motivation	15	Interaction/Communication	27
Personality	16	Length of Association	28
Task Complexity	17	Feedback/KR	30
Load	18	Homogeneity	32
Fidelity	19	Practice	33
Task Structure	20	Member Replacement	34
Communication Structure	21	Team vs. Automatic Control	35
Cooperation/Competition	22	Goal Expectations	37
		Miscellaneous	38
		Supervision & Leadership	37

*Several independent variable code numbers do not appear in the data file (e.g., #34 Member Replacement), primarily because they were applicable to a study for which only interactions were available and thus more than one independent variable was involved.

APPENDIX C

Lotus Spreadsheet Headings for 25 Fields By Field Letter Designation

Field	Heading	Field	Heading
A	I.D. Code	N	F-ratio
B	Coder (1,2, or 3)	O	Chi-Square
C	Journal (2 = Journal; 1,3,4,5,6 = Non-Journal)	P	Exp/Type (Field = 1,2; Lab = 3,4)
D	Subject Type (Military = 0; Non-Military = 1)	Q	Team Size
E	Year of Publication	R	Statistical Code**
*F	Substant/Q1 (1-5 rating)	S	Vote**
G	Design/Q1 (1-5 rating)	T	Independent Variable (Description)
H	Rept/Q1 (1-5 rating)	U	Dep. Variable (Descript.)
I	Effect Size (r's)	V	Study Outcome (Descript.)
J	Eta	W	Indep. Variable (Code #)
K	df/numerator	X	Dep. Variable (Code #)
L	df/denominator	Y	Effect Size (r pt.bis)***
M	t		

* 1 - lo; 5 - hi Quality Rating

** See codesheet; Appendix A

*** Used for meta-analysis

APPENDIX D

STUDIES IN DATA BASE FROM WHICH QUANTITATIVE FINDINGS WERE OBTAINED FOR META-ANALYSIS*

- Ainsworth, L. L., & Bishop, H. P. (1971). The effects of a 48-hour period of sustained field activity on tank crew performance (Technical Report 71-16). Alexandria, VA: Human Resources Research Organization. (Article Code #: 1178)**
- Altman, I., & Haythorn, W. W. (1967). The effects of social isolation and group composition on performance. Human Relations, 20, 313-340. (Article Code #: 1152)
- Baldwin, R. D., et al. (1970, August). Aircraft recognition performance of crew chiefs with or without forward observers (HumRRO Technical Report 70-12). Alexandria, VA: Human Resources Organization. (Article Code #: 1087)
- Banks, J. H., Hardy, G. D., Jr., Scott, T. D., & Jennings, J. W. (1975). Elements of a battalion integrated sensor system: Operator and team effectiveness (Research Report 1187). Arlington, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (Article Code #: 1168)
- Basar, T., Cruz, J. B., Jr., & Cansever, D. (1983). A minimum sensitivity incentive control approach to team problems. Proceeding of the MIT/ONR Workshop on C3 (Command, Control, and Communications) Systems (6th) held at Cambridge, MA, July 25-29, 1983. (Article Code #: 4029)
- Bauer, R. W., & Walkush, T. J. (1976). Crew station and skill level assessments for the MICV/ARSV. (Article Code #: 1004)
- Beare, A. N., & Gray, L. H. (1984). Simulator experiments: Effects of NPP operator experience on performance. Presentation made at 12th Water Reactor Safety Information Meeting, National Bureau of Standards, Washington, DC, October 22-26, 1984. (Article Code #: 5003)
- Billings, C. E., & Cheaney, E. S., (Eds.). (1981). Information transfer problems in the aviation system. Washington, DC: National Aeronautics and Space Administration. (Article Code #: 6002)

*Findings appear in spreadsheet format on the computer disk for these studies. Those that entered into the meta-analysis are the ones that met the criteria defined in the text.

**Article code numbers match the ID numbers for the article that appear in the spreadsheet.

- Bird, A. M. (1977). Team structure and success as related to cohesiveness and leadership. Journal of Social Psychology, 103, 217-223. (Article Code #: 1006)
- Bird, A., Foster, C., & Maruyama, G. (1980). Convergent and incremental effects of cohesion on attributions for self and team. Journal of Sports Psychology, 2, 181-194. (Article Code #: 7009)
- Briggs, G. E., & Johnston, W. A. (1965). Team training research (Technical Report NAVTRADEVCEEN 1327-2). Columbus, OH: Human Performance Center, Ohio State University. (Article Code #: 1086)
- Briggs, G. E., & Johnston, W. A. (1966). Stimulus and response fidelity in team training. Journal of Applied Psychology, 50(2), 114-117. (Article Code #: 1013)
- Briggs, G. E., & Naylor, J. C. (1964). Experiments on team training in a CIC-type task environment (Technical Report NAVTRADEVCEEN 1327-1). Columbus, OH: The Ohio State University. (Article Code #: 1012)
- Briggs, G. E., & Naylor, J. C. (1965). Team versus individual training, training task fidelity, and task organization effects on transfer performance by three-man teams. Journal of Applied Psychology, 49(6), 387-392. (Article Code #: 1011)
- Briggs, G. E., & Johnston, W. A. (1966). Influence of a change in system criteria on team performance. Journal of Applied Psychology, 50(6), 467-472. (Article Code #: 1009)
- Briggs, G. E., & Johnston, W. A. (1967). Team training. Final Technical Report, February 1966-February 1967 (NAVTRADEVCEEN-1327-4). Orlando, FL: Naval Training Device Center. (Article Code #: 1010)
- Brown, C. E., & Leupp, D. G. (1985). Team performance with large and small screen displays (AAMRL-TR-85-033). Wright-Patterson Air Force Base, OH: Harry G. Armstrong Aerospace Medical Research Laboratory, Aerospace Medical Division. (Article Code #: 1016)
- Brown, C. E., Jennings, L. S., & Ward, S. L. (1984). Team problem-solving: Leader proficiency, communication, and co-workers functions. Air Force Aerospace Medical Research Laboratory. (Article Code #: 1015)
- Carron, A. V., Ball, J. R., & Chelladurai, P. (1977). Motivation for participation, success in performance and their relationship to individual and group satisfaction. Perceptual and Motor Skills, 45, 835-841. (Article Code #: 1017)
- Chapanis, A., Ochsman, R. B., Parrish, R. N., & Weeks, G. D. (1972). Studies in interactive communication: I. The effects of four communication modes on the behavior of teams during cooperative problem solving. Human Factors, 14(6), 487-509. (Article Code #: 1018)

- Chapman, L. J., & Campbell, D. T. (1957). An attempt to predict the performance of three-man teams from attitude measures. Journal of Social Psychology, 46, 277-286. (Article Code #: 1119)
- Cockrell, J. T. (1969). Maintaining target detection proficiency through team consensus feedback (BESRL Technical Research Note 219). Arlington, VA: U.S. Army Behavioral Science Research Laboratory. (Article Code #: 1149)
- Cockrell, J. T., & Sadacca, R. (1968). Maintaining image interpreter proficiency through team consensus feedback (Technical Research Note 195). Washington, DC: U.S. Army behavioral Science Research Laboratory. (Article Code #: 1159)
- Crombag, H. F. (1966). Cooperation and competition in means-interdependent triads: A replication. Journal of Personality and Social Psychology, 4(6), 692-695. (Article Code #: 1115)
- Dailey, R. C. (1980). A path analysis of R & D team coordination and performance. Decision Sciences, 11, 357-369. (Article Code #: 4005)
- Doten, G. W., Cockrell, J. T., & Sadacca, R. (1966). The use of teams in image interpretation: Information exchange, confidence, and resolving difficulties (Report No. APRO-TRN-115). Washington, DC: U.S. Army Personnel Research Office. (Article Code #: 1020)
- Doten, G. W., & Sadacca, R. (1969). Team interpretation procedures: Selection of teammates and role assignment (Technical Research Note 201). Arlington, VA: U.S. Army Behavioral Science Research Laboratory. (Article Code #: 1156)
- Egerman, K. (1966). Effects of team arrangement on team performance: A learning theoretic analysis. Journal of Personality and Social Psychology, 3(5), 541-550. (Article Code #: 1021)
- Eitzen, D. S. (1973). The effect of group structure on the success of athletic teams. International Review of Sport Psychology, 8(1), 7-17. (Article Code #: 7011)
- Federman, P. J., & Siegel, A. I. (1965). Communication as a measurable index of team behavior (Tech Report NAVTRADEVCEEN 1537-1, Contract N61339-1537). Wayne, PA: Applied Psychological Services, Science Center. (Article Code #: 1142)
- Fiedler, F. E. (1954). Assumed similarity measures as predictors of team effectiveness. Journal of Abnormal and Social Psychology, 49, 381-388. (Part I: Article Code #: 7006; Part II: Article Code #: 7017)
- Fielding, L., Murray, J., & Steel, D. H. (1975). The influence of spectator reaction and presence during training on performance. International Journal of Sport Psychology, 7, 73-81. (Article Code #: 7004)

- Foushee, H. C., & Helmreich, R. L. (1982). Group interaction and flight crew performance. In E. L. Weiner & D. C. Nagel (Eds.), Human Factors in Aviation. New York: Academic Press. (Article Code #: 6008)
- Foushee, H. C., Lauber, J. K., Baetge, M. M., & Acomb, D. F. (1985). Crew factors in flight operations III: The operational significance of exposure to short-haul air transport operations (NASA Technical Memorandum 88322). (Article Code #: 6006)
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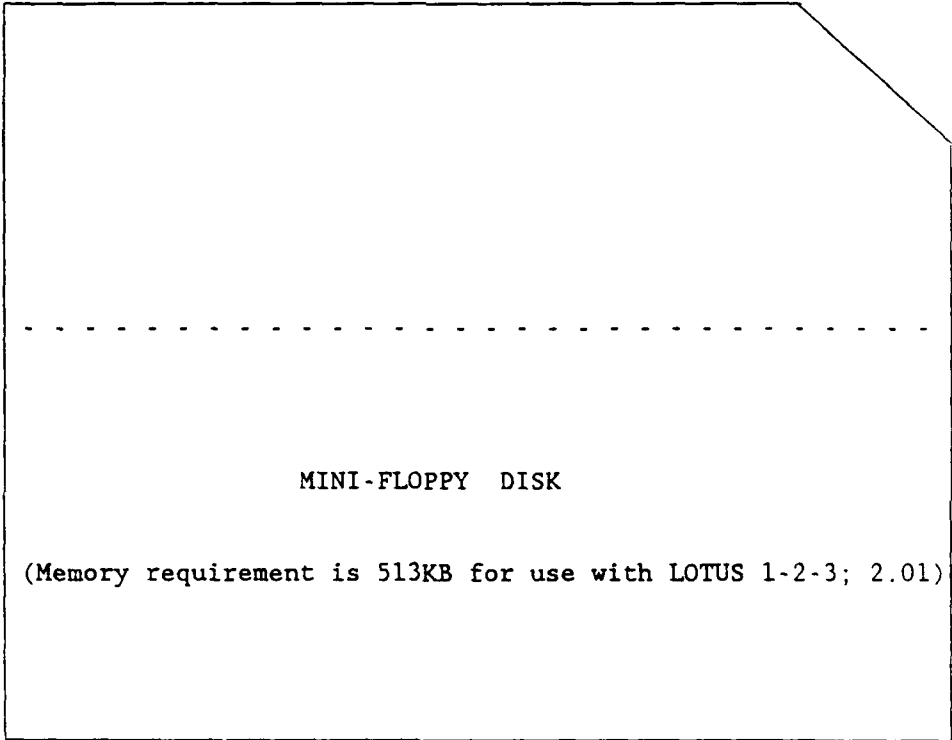
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APPENDIX E

Team Performance Data Base Disk*



MINI-FLOPPY DISK

(Memory requirement is 513KB for use with LOTUS 1-2-3; 2.01)

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